MOD09 (Surface Reflectance) User's Guide

MODIS Land Surface Reflectance Science Computing Facility

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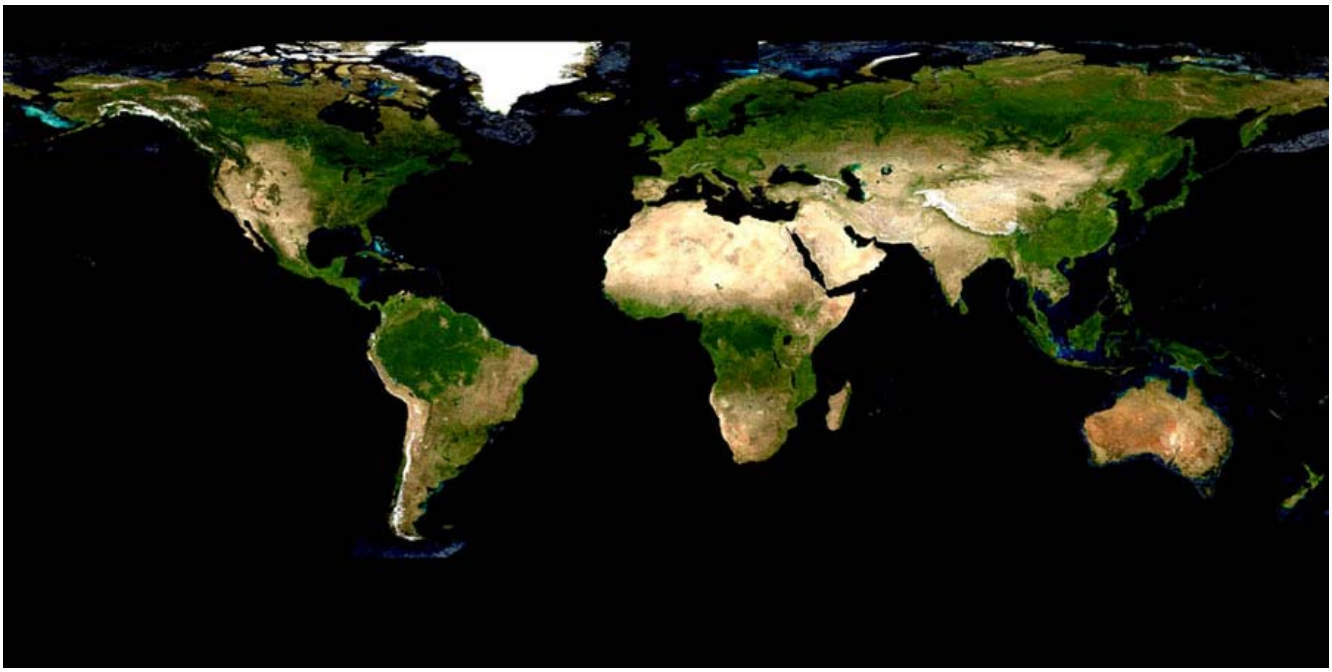

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If there is something else you would like to see in the MOD09 User's Guide, please write to us at mod09@ltdri.org. We will be happy to consider your suggestions!

Notes:

a) A number of significant improvements have also been introduced into the AC algorithm, including the LUT-format modification for a more accurate interpolation of atmospheric parameters and the use of dynamic aerosol models and ocean bands for improved aerosol retrieval over land surface. A detailed description of these changes can be found at the MODIS Land Quality Assessment Web site (http://landweb.nascom.nasa.gov/cgi-bin/QA_WWW/newPage.cgi).

b) Please check the product availability on our Web site at http://modis-sr.ltdri.org.

1. Product description

MOD09 (MODIS Surface Reflectance) is a seven-band product computed from the MODIS Level 1B land bands 1 (620-670 nm), 2 (841-876 nm), 3 (459-479), 4 (545-565 nm), 5 (1230-1250 nm), 6 (1628-1652 nm), and 7 (2105-2155 nm). The product is an estimate of the surface spectral reflectance for each band as it would have been measured at ground level as if there were no atmospheric scattering or absorption. It corrects for the effects of atmospheric gases, aerosols, and thin cirrus clouds.

2. List of products

Collection 4

Product Full Name	Product Abbreviation	
	Terra	Aqua
Surface Reflectance Daily L2G Global 250 m	MOD09GQK	MYD09GQK
Surface Reflectance Daily L2G Global 500 m	MOD09GHK	MYD09GHK
Surface Reflectance 8-Day L3 Global 250 m	MOD09Q1	MYD09Q1
Surface Reflectance 8-Day L3 Global 500 m	MOD09A1	MYD09A1
Surface Reflectance Quality Daily L2G Global 1km	MOD09GST	MYD09GST

Collection 5

Product Full Name	Product Abbreviation	
	Terra	Aqua
Surface Reflectance Daily L2G Global 250 m	MOD09GQ	MYD09GQ
Surface Reflectance Daily L2G Global 500 m and 1 km	MOD09GA	MYD09GA
Surface Reflectance 8-Day L3 Global 250 m	MOD09Q1	MYD09Q1
Surface Reflectance 8-Day L3 Global 500 m	MOD09A1	MYD09A1
Surface Reflectance Daily L3 Global 0.05Deg CMG*	MOD09CMG	MYD09CMG

*CMG – Climate Modeling Grid

3. Differences between Collection 4 and Collection 5

The contents of MOD09 have been changed to meet the user's demand.

a) The Daily Surface Reflectance Quality product at 1-km resolution was incorporated into the Daily Surface Reflectance product at 500-m resolution.

b) The Daily Surface Reflectance products at 500-m and 1-km resolution have new abbreviated names.

c) A new product called Global Daily Surface Reflectance at 0.05° resolution was created. This product is applied on a Climate Modeling Grid (CMG) for the purpose of being used in climate simulation models.

4. Data ordering (& browsing)

a) EOS (Earth Observing System) Data Gateway

The main source of data, a "place an order" database, a quick-start tutorial.

Link: http://edcimswww.cr.usgs.gov/pub/imswelcome/

b) LP DAAC (Land Processes Distributed Active Archive Center)

Useful information and links, ftp-access to a subset of MODIS land products.

Link: http://edcdaac.usgs.gov/main.asp

c) US Geological Survey (USGS) Global Visualization (GloVIS)

Access to selected MODIS land products with browse capability.

Link: http://glovis.usgs.gov/

d) MODIS Land Global Browse Images

5-km versions of selected product to enable synoptic quality assessment.

Link: http://landweb.nascom.nasa.gov/cgi-bin/browse/browse.cgi

e) Earth Science Data Interface (ESDI) at the Global Land Cover Facility

32-day composites, images in GeoTiff format, limited products.

Link: http://landcover.org/index.shtml

5. Data viewing tools

a) Imager (platform: Linux)

A software tool specifically designed by the MODIS LSR SCF for viewing surface reflectance suites.

Link: http://modis-sr.ltdri.org/MAIN_MODIS_SOFTWARE/IMAGER.html

b) HDFLook (platforms: SUN, AIX, SGI, Linux, MacOSX, Cygwin)

A multifunctional data processing and visualization tool for land, ocean and atmosphere MODIS data.

Link: http://www-loa.univ-lille1.fr/Hdflook/hdflook_gb.html

c) ENVI (platforms: Windows & Linux)

A software for the visualization, analysis, and presentation of all types of digital imagery.

Link: http://www.ittvis.com/envi/

d) HDF Explorer (platform: Windows)

A software environment where data are first viewed in a tree-like interface, and then optionally loaded and visualized in a variety of ways.

Link: http://www.space-research.org/

6. Data product granule ID

Example 1: MOD09GHK.A2006351.h18v06.004.2006353163945.hdf

MOD09GHK: product name (MODIS Terra Surface Reflectance Daily L2G Global 500 m)

A2000351: Acquisition year (2006) and Julian day (351)

h18v06: tile ID (see MODIS sinusoidal grid)

004: Collection 4

2006353163945: Production year (2006), Julian day (353), and time (16:39:45)

Example 2: MOD09CMG.A2000338.005.2006332091104.hdf

MOD09CMG: product name (MODIS Terra Surface Reflectance Daily L3 Global 0.05Deg. CMG)

A2000338: Acquisition year (2000) and Julian day (338)

005: Collection 5

2006332091104: Production year (2006), Julian day (332), and time (09:11:04)

7. Data product grids

7.1. MODIS sinusoidal grid

The Earth's surface is divided into tiles (10° x 10°).

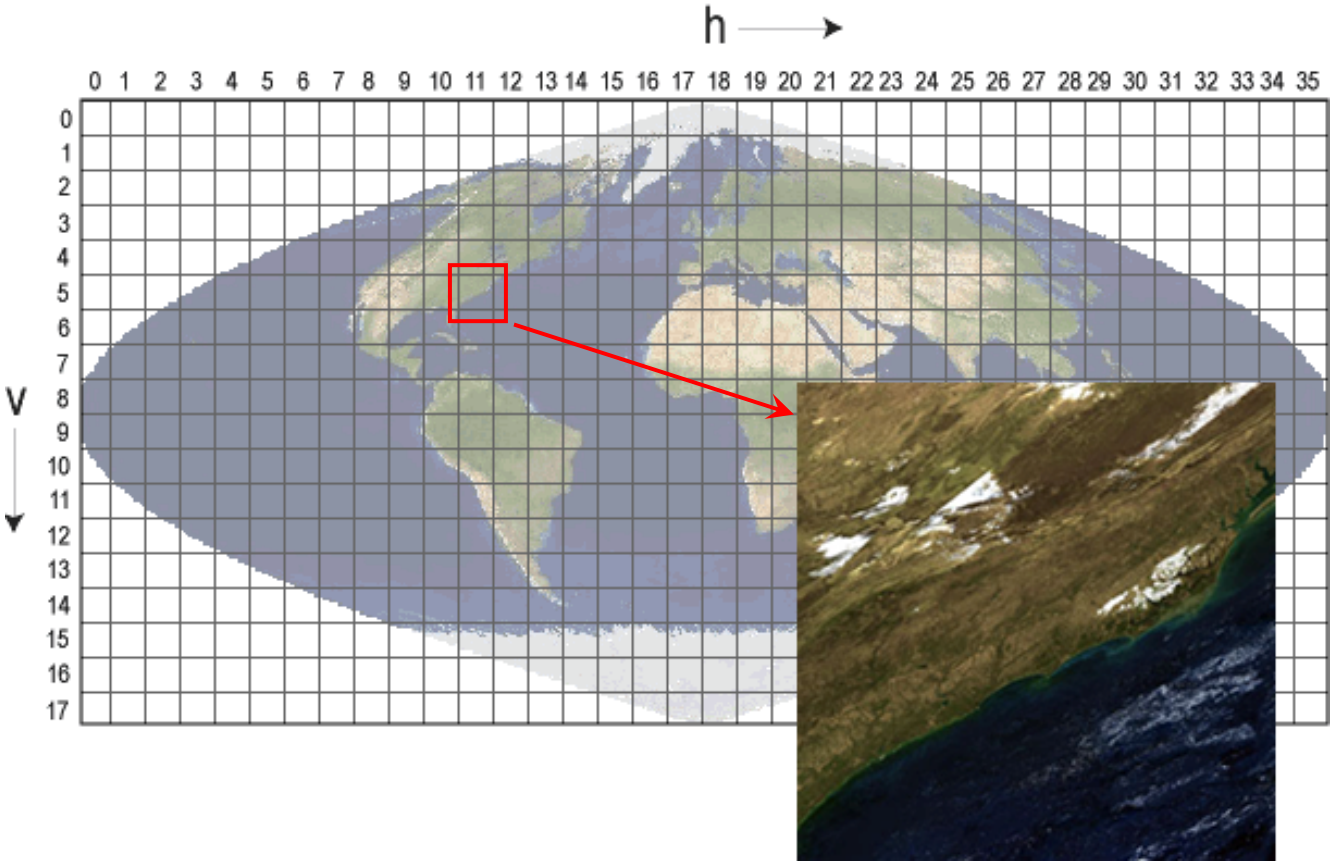


Figure 1. The MODIS sinusoidal grid with an example tile shown as a RGB-image produced from the MODIS data acquired on December 3, 2006 over the US East cost. This product Granule ID is MOD09A1.A2000337.h11v05.005.2006342055602.hdf.

7.2. Climate Modeling Grid (CMG)

The resolution of CMG is 0.05°. This grid is primarily used in climate studies.

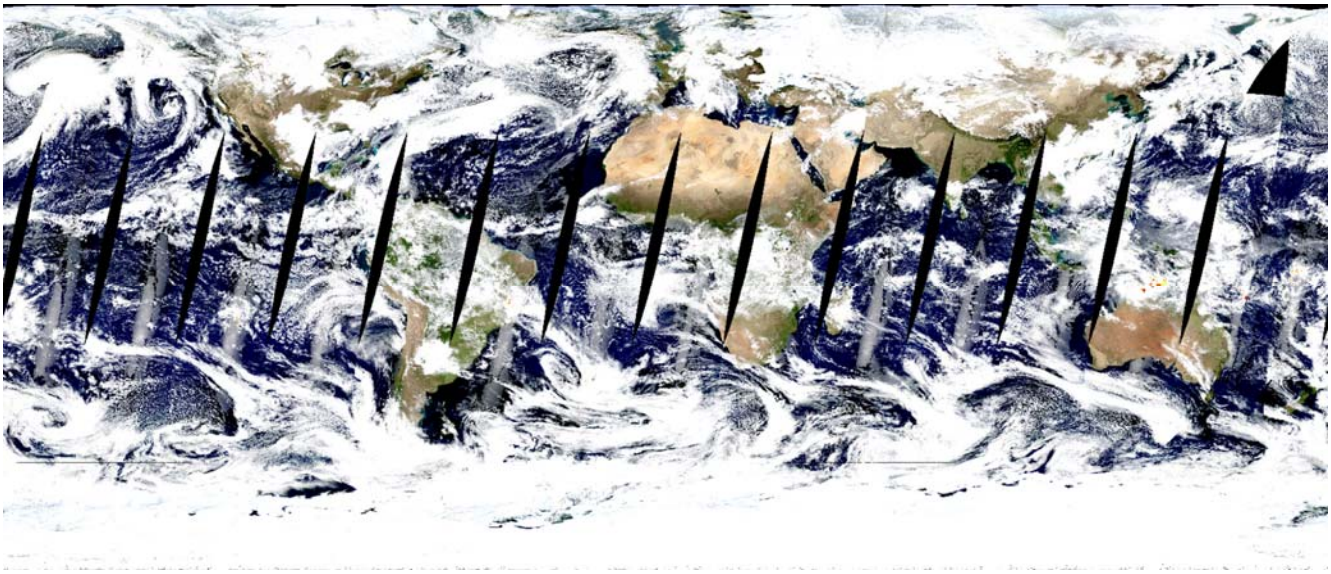


Figure 2. An example of MODIS product based on the Climate Modeling Grid. The shown RGB-color image was produced from the MODIS data acquired on December 4, 2000. The product granule ID is MOD09CMG.A2000338.005.2006332091104.hdf.

8. Data product structure

8.1. Description and Science Data Sets (Collection 5)

8.1.1. MOD09GQ / MYD09GQ

MODIS Terra/Aqua Surface Reflectance Daily L2G Global 250 m

Product description: MOD09GQ (MYD09GQ) provides MODIS band 1-2 daily surface reflectance at 250-m resolution. This product is meant to be used in conjunction with the MOD09GA where important quality and viewing geometry information is stored.

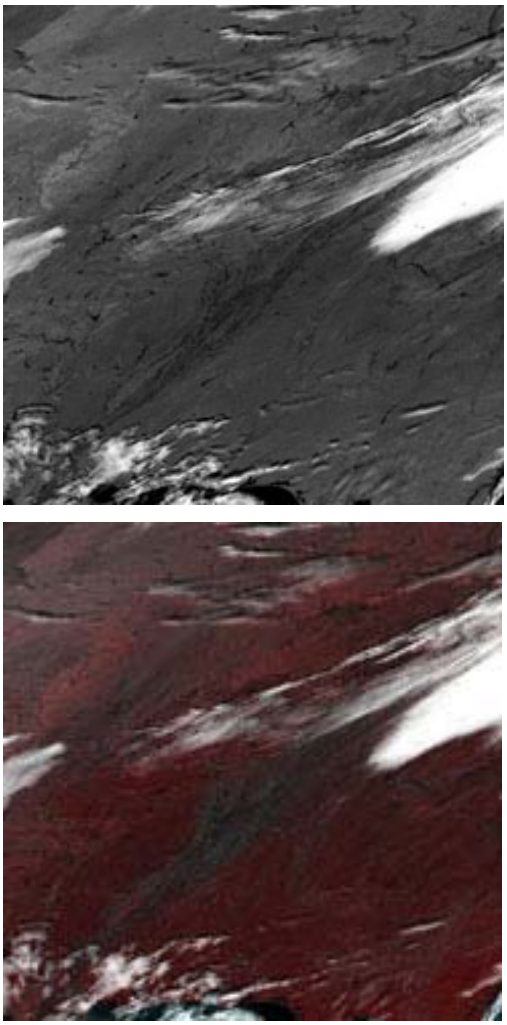


Figure 3. An example of MOD09GQ surface reflectance product. The corresponding MODIS data were collected on December 3, 2000 over the US territory (in particular, over Alabama, Mississippi and Florida). Product Granule ID: MOD09GQ.A2000339.h10v05.005.2006339053418.hdf. ***Upper image:*** Band 2 (near-infrared) surface reflectance shown on a gray scale. ***Lower image:*** A false-color RGB combination of bands 2, 1, and 1. Vegetation appears red, water appears blue, and clouds appears white. A land/sea mask has been used to remove deep ocean water which appears black.

Table 1. Science Data Sets for MOD09GQ / MYD09GQ.

Science Data Sets (HDF Layers) (5)	Units	Bit Type	Fill Value	Valid Range	Scale Factor
num_observations: number of observations within a pixel	None	8-bit signed integer	-1	0 - 127	NA
250m Surface Reflectance Band 1 (620-670 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
250m Surface Reflectance Band 2 (841-876 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
250m Reflectance Band Quality (*see Table 11*)	Bit Field	16-bit unsigned integer	2995	0 - 4096	NA
obs_cov: Observation Coverage (percentage of the grid cell area covered by the observation)	Percent	8-bit signed integer	-1	0 - 100	(0.001) 0.009999999776482582

8.1.2. MOD09GA / MYD09GA

MODIS Terra/Aqua Surface Reflectance Daily L2G Global 500 m and 1 km

Product description: MOD09GA (MYD09GA) provides MODIS band 1-7 daily surface reflectance at 500-m resolution and 1-km observation and geolocation statistics.

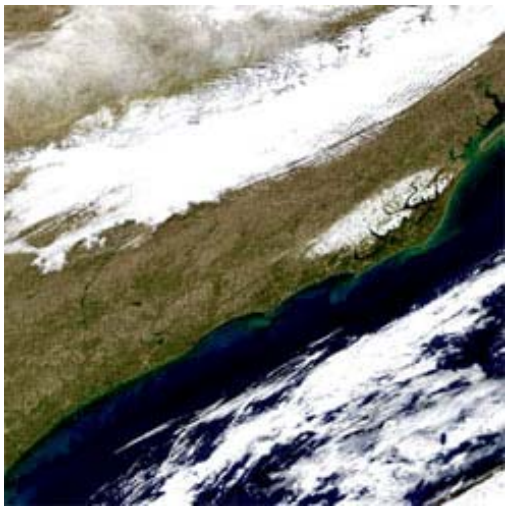


Figure 4. A MOD09GA RGB-image composed of surface reflectance measured by MODIS bands 1 (red), 4 (green) and 3 (blue) on December 6, 2000 over the US East coast. Product granule ID: MOD09GA.A2000340.h11v05.005.2006339102700.hdf

Table 2. Science Data Sets for MOD09GA / MYD09GA.

Data Group	Science Data Sets (HDF Layers (21))	Units	Bit Type	Fill Value	Valid Range	Scale Factor
1 km	num_observations_1km: Number of Observations	NA	8-bit signed integer	-1	0 - 127	NA
	State_1km: Reflectance Data State (*see Table 13*)	Bit Field	16-bit unsigned integer	65535	0 - 57335	NA
	Sensor Zenith Angle	Degree	16-bit signed integer	-32767	0 - 18000	0.01
	Sensor Azimuth Angle	Degree	16-bit signed integer	-32767	-18000 - 18000	0.01
	Range: pixel to sensor	Meter	16-bit unsigned integer	65535	27000 - 65535	25
	Solar Zenith Angle	Degree	16-bit signed integer	-32767	0 - 18000	0.01
	Solar Azimuth Angle	Degree	16-bit signed integer	-32767	-18000 - 18000	0.01
	gflags: Geolocation flags (*see Table 15*)	Bit Field	8-bit unsigned integer	255	0 - 248	NA
	orbit_pnt: Orbit Pointer	none	8-bit signed integer	-1	0 - 15	NA
*****	**********	********	**********	********	**********	*********

500 m	num_observations_500m	none	8-bit signed integer	-1	0 - 127	NA
	sur_refl_b01: 500m Surface Reflectance Band 1 (620-670 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	sur_refl_b02: 500m Surface Reflectance Band 2 (841-876 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	sur_refl_b03: 500m Surface Reflectance Band 3 (459-479 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	sur_refl_b04: 500m Surface Reflectance Band 4 (545-565 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	sur_refl_b05: 500m Surface Reflectance Band 5 (1230-1250 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	sur_refl_b06: 500m Surface Reflectance Band 6 (1628-1652 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	sur_refl_b07: 500m Surface Reflectance Band 7 (2105-2155 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
	QC_500m: 500m Reflectance Band Quality (*see Table 12*)	Bit Field	32-bit unsigned integer	787410671	0 - 4294966019	NA
	Obs_cov_500m: Observation coverage	Percent	8-bit signed integer	-1	0 - 100	(0.01) 0.009999977648258
	iobs_res: Observation number	none	8-bit unsigned integer	255	0 - 254	NA
	q_scan: 250m scan value information (*see Table 16*)	Bit Field	8-bit unsigned integer	255	0 - 255	NA

8.1.3. MOD09Q1 / MYD09Q1

MODIS Terra/Aqua Surface Reflectance 8-Day L3 Global 250 m

Product description: MOD09Q1 (MYD09Q1) provides MODIS band 1-2 surface reflectance at 250-m resolution. It is a level-3 composite of MOD09GQ (MYD09GQ). Each MOD09Q1 (MYD09Q1) pixel contains the best possible L2G observation during an 8-day period as selected on the basis of high observation coverage, low view angle, the absence of clouds or cloud shadow, and aerosol loading.

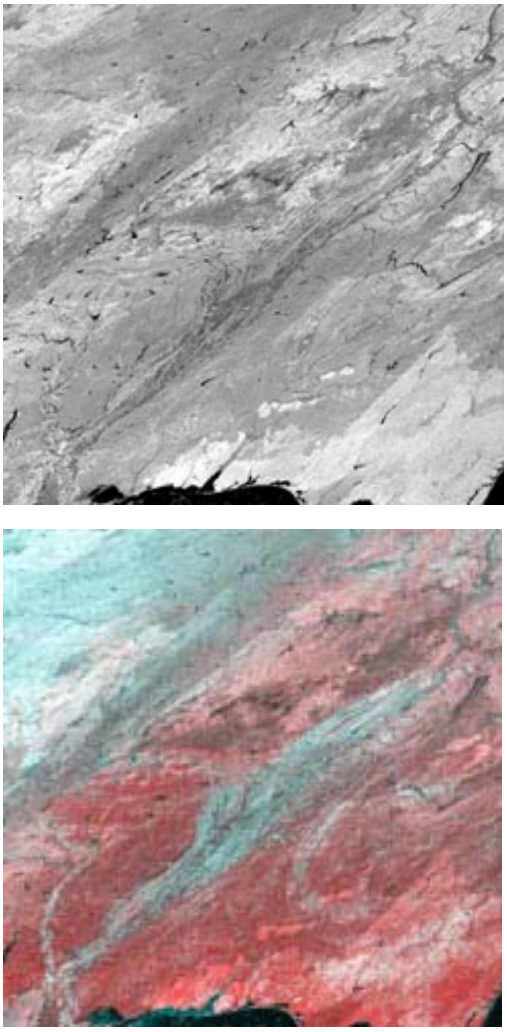


Figure 5. An example of MOD09Q1 surface reflectance product. The corresponding MODIS data were collected in December, 2000 over the US territory (in particular, over Alabama, Mississippi and Florida). Product Granule ID: MOD09Q1.A2000337.h10v05.005.2006342044337.hdf. ***Upper image:*** Band 2 (near-infrared) surface reflectance shown on a gray scale. ***Lower image:*** A false-color RGB combination of bands 2, 1, and 1. Vegetation appears red, water appears blue, and clouds appears white. A land/sea mask has been used to remove deep ocean water which appears black.

Table 3. Science Data Sets for MOD09Q1 / MYD09Q1

Science Data Sets (HDF Layers (3))	Units	Bit Type	Fill Value	Valid Range	Scale Factor
250m Surface Reflectance Band 1 (620-670 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
250m Surface Reflectance Band 2 (841-876 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
250m Reflectance Band Quality (*see Table 11*)	Bit Field	16-bit unsigned integer	65535	0 - 32767	NA

8.1.4. MOD09A1 / MYD09A1

MODIS Terra/Aqua Surface Reflectance 8-Day L3 Global 500 m

Product description: MOD09A1 (MYD09A1) provides MODIS band 1-7 surface reflectance at 500 m resolution. It is a level-3 composite of 500-m resolution MOD09GA (MYD09GA). Each product pixel contains the best possible L2G observation during an 8-day period as selected on the basis of high observation coverage, low view angle, absence of clouds or cloud shadow, and aerosol loading.

Figure 6. A MOD09A1 RGB image composed of surface reflectance data measured by bands 1 (red), 4 (green) and 3(blue) in December, 2000 over the US East coast. Granule ID: MOD09A1.A2000337.h11v05.005.2006342055602.hdf

Table 4. Science Data Sets for MOD09A1 / MYD09A1

Science Data Sets (HDF Layers (13))	Units	Bit Type	Fill Value	Valid Range	Scale Factor
500m Surface Reflectance Band 1 (620-670 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
500m Surface Reflectance Band 2 (841-876 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
500m Surface Reflectance Band 3 (459-479 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
500m Surface Reflectance Band 4 (545-565 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
500m Surface Reflectance Band 5 (1230-1250 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
500m Surface Reflectance Band 6 (1628-1652 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
500m Surface Reflectance Band 7 (2105-2155 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
500m Reflectance Band Quality (*see Table 12*)	Bit Field	32-bit unsigned integer	4294967295	0 - 4294966531	NA
Solar Zenith Angle	Degree	16-bit signed integer	0	0 - 18000	0.01
View Zenith Angle	Degree	16-bit signed integer	0	0 - 18000	0.01
Relative Azimuth Angle	Degree	16-bit signed integer	0	-18000 - 18000	0.01
500m State Flags (*see Table 13*)	Bit field	16-bit unsigned integer	65535	0 - 57343	NA
Day of Year	Julian day	16-bit unsigned integer	65535	1 - 366	NA

8.1.5. MOD09CMG / MYD09CMG

MODIS Terra/Aqua Surface Reflectance Daily L3 Global 0.05Deg CMG

Product description: MOD09CMG (MYD09CMG) provides MODIS band 1-7 surface reflectance at 0.05-degree resolution. This product is based on a Climate Modeling Grid (CMG) for the purpose of being used in climate simulation models.

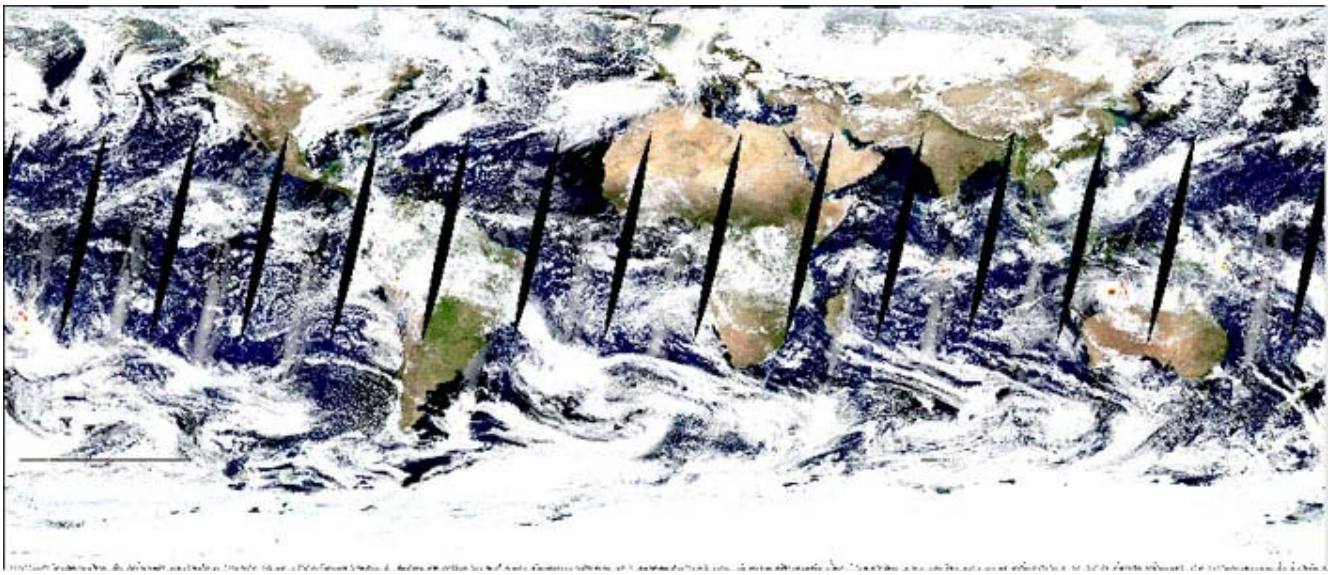


Figure 7. A MOD09CMG RGB-image composed of surface reflectance data measured by bands 1 (red), 4 (green) and 3 (blue) on December 7, 2000. The MODIS product granule ID is MOD09CMG.A2000341.005.2006347161131.hdf.

Table 5. Science Data Sets for MOD09CMG / MYD09CMG.

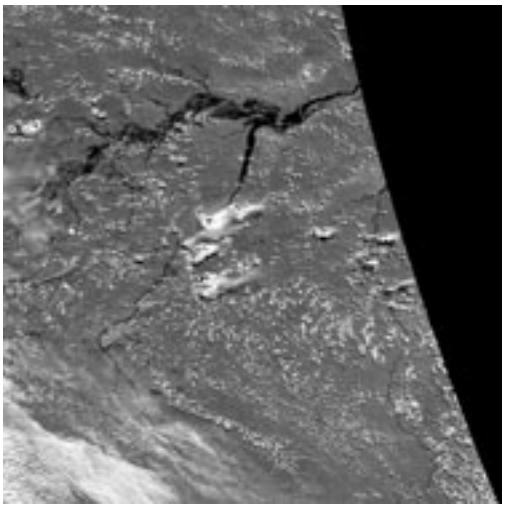
Science Data Sets (HDF Layers (19))	Units	Bit Type	Fill Value	Valid Range	Scale Factor
Coarse Resolution Surface Reflectance Band 1 (620-670 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Coarse Resolution Surface Reflectance Band 2 (841-876 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Coarse Resolution Surface Reflectance Band 3 (459-479 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Coarse Resolution Surface Reflectance Band 4 (545-565 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Coarse Resolution Surface Reflectance Band 5 (1230-1250 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Coarse Resolution Surface Reflectance Band 6 (1628-1652 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Coarse Resolution Surface Reflectance Band 7 (2105-2155 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Coarse Resolution Solar Zenith Angle	Degree	16-bit signed integer	0	0 - 18000	0.01
Coarse Resolution View Zenith Angle	Degree	16-bit signed integer	0	0 - 18000	0.01
Coarse Resolution Relative Azimuth Angle	Degree	16-bit signed integer	0	-18000 - 18000	0.01
Coarse Resolution Ozone	cm atm	8-bit unsigned integer	0	0 -255	400
Coarse Resolution Brightness Temperature Band 20 (3.360-3.840 µm)	degrees K	16-bit unsigned integer	0	0 - 40000	100
Coarse Resolution Brightness Temperature Band 21 (3.929-3.989 µm)	degrees K	16-bit unsigned integer	0	0 - 40000	100
Coarse Resolution Brightness Temperature Band 31 (10.780-11.280 µm)	degrees K	16-bit unsigned integer	0	0 - 40000	100
Coarse Resolution Brightness Temperature Band 32 (11.770-12.270 µm)	degrees K	16-bit unsigned integer	0	0 - 40000	100
Coarse Resolution Granule Time	HHMM	16-bit integer	0	0 - 2355	1
Coarse Resolution QA (*see Table 12*)	Bit Field	32-bit unsigned integer	0	0 - 1073741824	NA
Coarse Resolution Internal CM (*see Table 17*)	Bit Field	16-bit unsigned integer	0	1 - 8191	NA
Averaged Number of Pixels	unitless	8-bit unsigned integer	0	1 - 40	NA

8.2. Description and Science Data Sets (Collection 4)

8.2.1. MOD09GQK / MYD09GQK

MODIS Terra/Aqua Surface Reflectance Daily L2G Global 250 m

Product description: MOD09GQK (MYD09GQK) provides MODIS band 1-2 daily surface reflectance at 250-m resolution. The best observations during a 24-hour period, as determined by overall pixel quality and observational coverage, are matched geographically according to corresponding 250-m Pointer Files (MODPTQKM (*see Section 9*)). Quality information for this product is provided at three different levels of detail: for individual pixels, for each band and each resolution, and for the whole file.



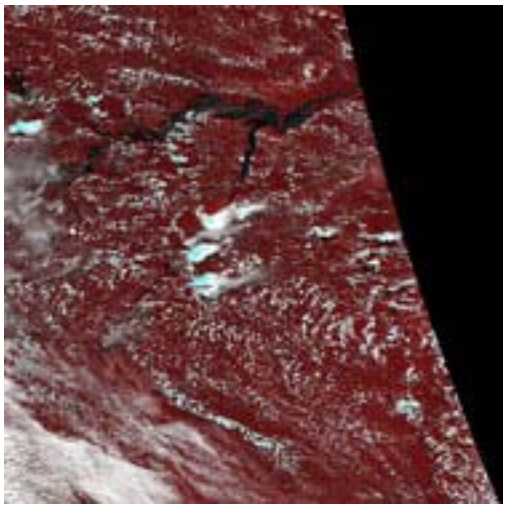


Figure 8. An example of MYD09GQK surface reflectance product. The corresponding MODIS data were collected on May 26, 2004 over Brazil, South America. Granule ID: MYD09GQK.A2004148.h12v09.004.2004151002653.hdf. ***Upper image:*** Band 2 (near-infrared) Surface Reflectance shown on a gray scale. ***Lower image:*** A false-color RGB combination of bands 2, 1, and 1. Vegetation appears red, water appears blue, and clouds appears white. A land/sea mask has been used to remove deep ocean water which appears black.

Table 6. Science Data Sets for MOD09GQK / MYD09GQK

Science Data Sets (HDF Layers) (5)	Units	Data Type	Fill Value	Valid Range	Scale Factor (divide by)
250m Surface Reflectance Band 1 (620-670 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	10000
250m Surface Reflectance Band 2 (841-876 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	10000
250m Reflectance Band Quality (*see Table 11*)	Bit field	16-bit unsigned integer	2995	0 - 4096	NA
Orbit and coverage (*see Table 18*)	Bit field	8-bit unsigned integer	15	0 - 255	NA
Number of Observations	NA	8-bit signed integer	-1	0 - 127	NA

8.2.2. MOD09GHK / MYD09GHK

MODIS Terra/Aqua Surface Reflectance Daily L2G Global 500 m

Product description: MOD09GHK (MYD09GHK) provides surface reflectance data at 250-m resolution for bands 1-2 and at 500-m resolution for bands 3-7. The best observations during a 24-hour period, as determined by overall pixel quality and observational coverage, are matched geographically according to corresponding 500-m Pointer Files (MODPTHKM (*see Section 9*). Quality information for this product is provided at three different levels of detail: for individual pixels, for each band and each resolution, and for the whole file.

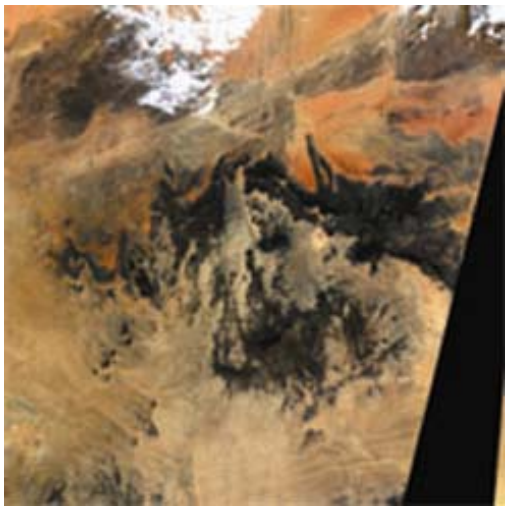


Figure 9. A MOD09GHK RGB-image composed of surface reflectance measured by bands 1 (red), 4 (green) and 3 (blue) on December 17, 2000 Sahara, Africa. Granule ID: MOD09GHK.A2006351.h18v06.004.2006353163945.hdf

Table 7. Science Data Sets for MOD09GHK / MYD09GHK

Science Data Sets (HDF Layers (10))	Units	Data Type	Fill Value	Valid Range	Scale Factor (divide by)
250m Surface Reflectance Band 1 (620-670 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	10000
250m Surface Reflectance Band 2 (841-876 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	10000
500m Surface Reflectance Band 3 (459-479 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	10000
500m Surface Reflectance Band 4 (545-565 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	10000
500m Surface Reflectance Band 5 (1230-1250 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	10000
500m Surface Reflectance Band 6 (1628-1652 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	10000
500m Surface Reflectance Band 7 (2105-2155 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	10000
500m Reflectance Band Quality (*see Table 12*)	Bit field	32-bit unsigned integer	787410671	0 - 4294967296	NA
Orbit and coverage	Bit field	8-bit unsigned integer	15	0 - 255	NA
Number of Observations	NA	8-bit signed integer	-1	0 - 127	NA

8.2.3. MOD09Q1 / MYD09Q1

MODIS Terra/Aqua Surface Reflectance 8-Day L3 Global 250 m

Product description: MOD09Q1 (MYD09Q1) provides band 1-2 surface reflectance at 250 m resolution. It is a level-3 composite of MOD09GQK (MYD09GQK). The best observations during an 8-day period, as determined by overall pixel quality and observational coverage, are matched geographically according to corresponding 250-m Pointer Files (MODPTQKM (*see Section 9*)). Quality information for the MOD09Q1 product is provided at three different levels of detail: for individual pixels, for each band and each resolution, and for the whole file.

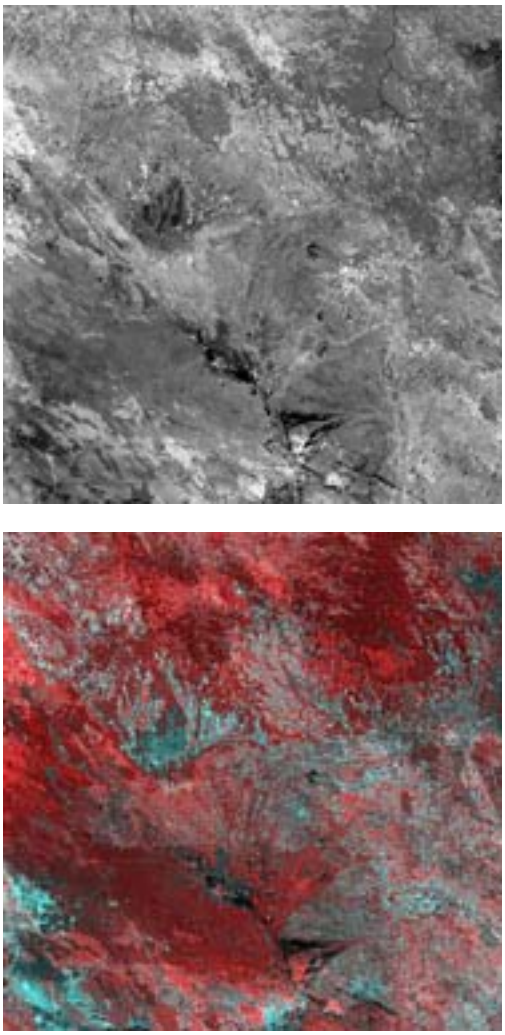


Figure 10. An example of MYD09GQK surface reflectance product. The corresponding MODIS data were collected in May 2004 mostly over Brazil, South America. Granule ID: MYD09Q1.A2004145.h12v10.004.2004157154243.hdf. ***Upper image:*** Band 2 (near-infrared) surface reflectance shown on a gray scale. ***Lower image:*** A false-color RGB combination of bands 2, 1, and 1. Vegetation appears red, water appears blue, and clouds appears white. A land/sea mask has been used to remove deep ocean water which appears black.

Table 8. Science Data Sets for MOD09Q1 / MYD09Q1

Science Data Sets (HDF Layers (3))	Units	Data Type	Fill Value	Valid Range	Scale Factor
Surface Reflectance for band 1 (620-670 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance for band 2 (841-876 nm)	Reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface reflectance 250m quality control flags (*see Table 11*)	Bit field	16-bit unsigned integer	65535	0-4294966531	NA

8.2.4. MOD09A1 / MYD09A1

MODIS Terra/Aqua Surface Reflectance 8-Day L3 Global 500 m

Product description: MOD09A1 (MYD09A1) is a composite of MOD09GHK (MYD09GHK). The best observations during an 8-day period, as determined by the overall pixel quality and observational coverage, are matched geographically according to corresponding 500-m Pointer Files (MODPTHKM (*see Section 9*)). Quality information for the MOD09A1 product is provided at three different levels of detail: for individual pixels, for each band and each resolution, and for the whole file.

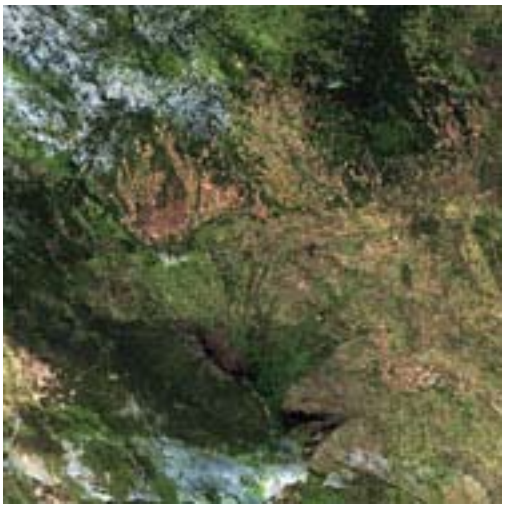


Figure 11. A MOD09A1 RGB-image composed of surface reflectance measured by bands 1 (red), 4 (green) and 3(blue) in May 2004 mostly over Brazil, South America. Granule ID: MYD09A1.A2004145.h12v10.004.2004157154243.hdf.

Table 9. Science Data Sets for MOD09A1 / MYD09A1

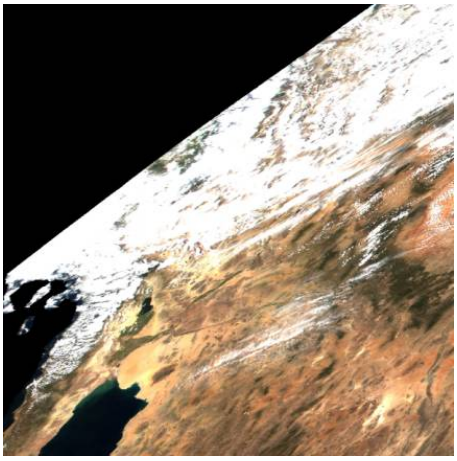
Science Data Sets (HDF Layers (13))	Units	Data Type-bit	Fill Value	Valid Range	Scale Factor
Surface Reflectance for band 1 (620-670 nm)	reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance for band 2 (841-876 nm)	reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance for band 3 (459-479 nm)	reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance for band 4 (545-565 nm)	reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance for band 5 (1230-1250 nm)	reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance for band 6 (1628-1652 nm)	reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface Reflectance for band 7 (2105-2155 nm)	reflectance	16-bit signed integer	-28672	-100 - 16000	0.0001
Surface reflectance 500m quality control flags (*see Table 12*)	Bit field	32-bit unsigned integer	4294967295	0 - 4294966531	NA
Solar zenith	Degree	16-bit signed integer	0	0 - 18000	0.01
View zenith	Degree	16-bit signed integer	0	0 - 18000	0.01
Relative azimuth	Degree	16-bit signed integer	0	-18000 - 18000	0.01
Surface reflectance 500m state flags (*see Table 13*)	Bit field	16-bit unsigned integer	65535	0	NA
Surface reflectance day of year	Julian Day	16-bit unsigned integer	65535	0 - 366	NA

8.2.5 MOD09GST / MYD09GST

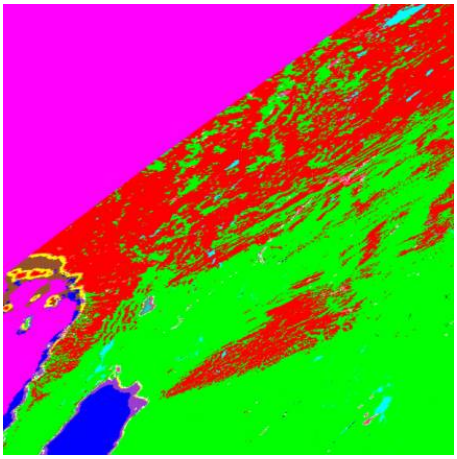
MODIS Terra/Aqua Surface Reflectance Quality Daily L2G Global 1 km

Product description: MOD09GST is a restructured version of the quality data in level-2 surface reflectance. It summarizes the quality of the MOD09 products, including atmospheric and other correction states. The product specifically contains information pertaining to cloud and cloud shadow, land and water designations, aerosols, and the data source of corrections performed on the file.

color	cloud value	land/sea value
magenta	[undefined]	[undefined]
violet	clear	shallow ocean
yellow	cloudy	shallow ocean
green	clear	land
red	cloudy	land
white	clear	coastlines/shorelines
coral	cloudy	coastlines/shorelines
plum	cloudy	shallow inland water
cyan	cloudy	ephemeral water
blue	clear	continental/moderate ocean
sienna	cloudy	continental/moderate ocean



MOD09GHK RGB-image



Corresponding information from MOD09GST

Figure 12. The table above interprets the colors used to display the MOD09GST surface reflectance data state product over MODIS tile h08v06 covering northern Mexico on April 4, 2000.

Table 10. Science Data Sets for MOD09GST / MYD09GST

Science Data Sets (HDF Layers (3))	Units	Data Type-bit	Fill Value	Valid Range
1km Reflectance Data State QA (*see Table 14*)	Bit field	16-bit unsigned integer	65535	0 - 65535
Orbit and coverage	Bit field	8-bit unsigned integer	15	0 - 255
Number of Observations	NA	8-bit signed integer	-1	0 - 127

8.3. Data product quality

8.3.1. 250-m resolution QA

Table 11. 250-m surface reflectance data QA description (16-bit).

Bit No.	Parameter Name	Bit Comb.	Sur_refl_qc_250m
0-1	MODLAND QA bits	00	corrected product produced at ideal quality all bands
		01	corrected product produced at less than ideal quality some or all bands
		10	corrected product not produced due to cloud effects all bands
		11	corrected product not produced due to other reasons some or all bands may be fill value [Note that a value of (11) overrides a value of (01)].
2-3=	cloud state	00	clear
		01	cloudy
		10	mixed
		11	not set; assumed clear
4-7	band 1 data quality four bit range	0000	highest quality
		1000	dead detector; data interpolated in L1B
		1001	solar zenith >= 86 degrees
		1010	solar zenith >= 85 and < 86 degrees
		1011	missing input
		1100	internal constant used in place of climatological data for at least one atmospheric constant
		1101	correction out of bounds, pixel constrained to extreme allowable value
		1110	L1B data faulty
		1111	not processed due to deep ocean or clouds
8-11=	band 2 data quality four bit range		SAME AS BAND ABOVE
12	atmospheric correction performed	1	yes
		0	no
13	adjacency correction performed	1	yes
		0	no
14-15	spare (unused)	-	---

8.3.2. 500-m and coarse resolution QA

Table 12. 500-m and coarse resolution surface reflectance data QA description (32-bit).

Bit No.	Parameter Name	Bit Comb.	QC_500m / Coarse Resolution QA
0-1	MODLAND QA bits	00	corrected product produced at ideal quality -- all bands
		01	corrected product produced at less than ideal quality -- some or all bands
		10	corrected product not produced due to cloud effects -- all bands
		11	corrected product not produced for other reasons -- some or all bands, may be fill value (11) [Note that a value of (11) overrides a value of (01)].
2-5	band 1 data quality, four bit range	0000	highest quality
		1000	dead detector; data interpolated in L1B
		1001	solar zenith >= 86 degrees
		1010	solar zenith >= 85 and < 86 degrees
		1011	missing input
		1100	internal constant used in place of climatological data for at least one atmospheric constant
		1101	correction out of bounds, pixel constrained to extreme allowable value
		1110	L1B data faulty
		1111	not processed due to deep ocean or clouds
6-9	band 2 data quality four bit range		same as band above
10-13	band 3 data quality four bit range		same as band above
14-17	band 4 data quality four bit range		same as band above
18-21	band 5 data quality four bit range		same as band above
22-25	band 6 data quality four bit range		same as band above
26-29	band 7 data quality four bit range		same as band above
30	atmospheric correction performed	1	yes
		0	no
31	adjacency correction performed	1	yes
		0	no

8.4. Data product state flags

8.4.1. 500-m and 1-km resolution data state QA (Collection 5)

Table 13. 500-m and 1-km resolution data state QA description (16-bit)

Bit No.	Parameter Name	Bit Comb.	state_1km
0-1	cloud state	00	clear
		01	cloudy
		10	mixed
		11	not set, assumed clear
2	cloud shadow	1	yes
		0	no
3-5	land/water flag	000	shallow ocean
		001	land
		010	ocean coastlines and lake shorelines
		011	shallow inland water
		100	ephemeral water
		101	deep inland water
		110	continental/moderate ocean
		111	deep ocean
6-7	aerosol quantity	00	climatology
		01	low
		10	average
		11	high
8-9	cirrus detected	00	none
		01	small
		10	average
		11	high
10	internal cloud algorithm flag	1	cloud
		0	no cloud
11	internal fire algorithm flag	1	fire
		0	no fire
12	MOD35 snow/ice flag	1	yes
		0	no
13	Pixel is adjacent to cloud	1	yes
		0	no

14	BRDF correction performed	1	yes
		0	no
15	internal snow mask	1	snow
		0	no snow

8.4.2. 1-km resolution data state QA (Collection 4)

Table 14. 1-km Surface Reflectance data state QA Description (16-bit) for Collection 4.

Bits 10-16 contain different information in Collection 4 product compared to Collection 5 product.

10	PGE11 cloud algorithm flag	1	clear
		0	cloudy
11	PGE11 fire algorithm flag	1	fire
		0	no fire
12	MOD35 snow/ice flag	1	yes
		0	no
13-14	BRDF correction performed	00	no
		01	Montana methodology
		10	Boston methodology
15	PGE11 snow algorithm flag	1	snow
		0	no snow

8.5. Geolocation flags (Collection 5)

Table 15. 1-kilometer geolocation flags (16-bit).

Bit No.	Description	Bit Comb.	state_1km
0-2	fill	00	Fill
3	Sensor range validity flag	0	Valid
		1	Invalid
4	Digital elevation model quality flag	0	Valid
		1	Missing/inferior
5	Terrain data validity	0	Valid
		1	Invalid
6	Ellipsoid intersection flag	0	Valid intersection
		1	No intersection
7	Input data flag	0	Valid
		1	Invalid

8.6. Scan value information (Collection 5)

Table 16. 250-m scan value information description (8-bit).

Bit No.	Parameter Name	Bit Comb.	q_scan
0	missing observation in quadrant 4 [+0.5 row, +0.5 column]	1	yes
		0	no
1	missing observation in quadrant 3 [+0.5 row, -0.5 column];	1	yes
		0	no
2	missing observation in quadrant 2 [-0.5 row, +0.5 column]	1	yes
		0	no
3	missing observation in quadrant 1 [-0.5 row, -0.5 column]	1	yes
		0	no
4	scan of observation in quadrant 4 [+0.5 row, +0.5 column]	1	same
		0	different
5	scan of observation in quadrant 3 [+0.5 row, +0.5 column]	1	same
		0	different
6	scan of observation in quadrant 2 [+0.5 row, +0.5 column]	1	same
		0	different
7	scan of observation in quadrant 1 [+0.5 row, +0.5 column]	1	same
		0	different

Note: The 250-m samples are for each of four quadrants within a 500-m cell. The first line/sample is in the upper left (north-west) corner of the image.

- 0 -- first 250m line (row), first 250m sample (column)
- 1 -- first 250m line, second 250m sample
- 2 -- second 250m line, first 250m sample
- 3 -- second 250m line, second 250m sample

8.7. Internal climatology (Collection 5)

Table 17. Coarse resolution internal CM (15-bit).

Bit No.	Description	Bit Comb.	state
0	cloudy	1	yes
		0	no
1	clear	1	yes
		0	no
2	high clouds	1	yes
		0	no
3	low clouds	1	yes
		0	no
4	snow	1	yes
		0	no
5	fire	1	yes
		0	no
6	sun glint	1	yes
		0	no
7	dust	1	yes
		0	no
8	cloud shadow	1	yes
		0	no
9	pixel is adjacent to cloud	1	yes
		0	no
10-11	cirrus	00	none
		01	small
		10	average
		11	high
12	pan flag	1	salt pan
		0	no salt pan
13	criteria used for aerosol retrieval	1	criterion 2
		0	criterion 1
14	AOT (aerosol optical thinkness) has climatological values	1	yes
		0	no
15	Unused	-	-

8.8. Orbit and coverage (Collection 4)

Table 18. Orbit and coverage data set (8-bit) for Collection 4 (the orbit the observation came from and the observation coverage).

Bit No.	Parameter Name	Bit Comb.	orb_cov_1
0-3	orbit number	range: from 0 to 13 key: from 0000 (0) to 1011 (13)	
4	scan half flag	0	top half
		1	bottom half
6-7	land/water flag	000	0.0 – 12.5%
		001	12.5 – 25.0%
		010	25.0 – 37.5%
		011	37.5 – 50.0%
		100	50.0 – 62.5%
		101	62.5 – 75.0%
		110	75.0 – 87.5%
		111	87.5 – 100.0%

Note: The orbit number is not the absolute orbit number but a relative orbit number in the file. In addition a flag is stored which distinguishes between observations which are in the top half of the scan (the first 5 1-km scan lines in the along track direction) and the bottom half of the scan (the last 5 1-km scan lines). The observation coverage is the area of intersection of observation footprint and cell divided by the area of the observation.

9. Useful links

a) 250-m Pointer Files (MODPTQKM)

Link: http://edcdaac.usgs.gov/modis/modptqkmv4.asp

b) 500-m Pointer Files (MODPTQKM)

Link: http://edcdaac.usgs.gov/modis/modptqkmv4.asp